

Appendix G: Test Procedure Peer Reviews

Comments in Peer Reviews of
Test Procedure for Determining Annual Flash Emission Rate of Methane
from Crude Oil, Condensate, and Produced Water,
Completed November 2016

Review of "Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate, and Produced Water Tank and Separator Systems"

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November 28, 2016

On August 10, 2016 Elizabeth Scheehle of the California Air Resources Board signed the memorandum: "Request for External Peer Review of the Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate, and Produced Water Tank and Separator Systems". In response, my review below was solicited by Dr. Gerald Bowes of the State Water Resources Control Board on October 26, 2016 and contains my professional opinion on this work. **Specifically, my report comments on Conclusion #3 of the memorandum "The Test Procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production separator and tank systems",** but also contains some additional scientific comments.

The report is part of a detailed plan to mitigate methane emissions associated with oil and natural gas production in California. A strong case is made that methane emissions can be significantly reduced using a combination of emissions avoidance, leak detection and repair, and replacement of specific components of the infrastructure.

In response to the conclusion **"The Test Procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production separator and tank systems",** I have the following comment:

Methane emissions, and the proposed reductions therein, are calculated based on activity (e.g. produced oil, natural gas and water) and emission factors for each of these processes. Activities are obtained from operator surveys and emission factors are, in part, determined from measurements in California described in the report. These are certainly defensible choices. However, there are uncertainties in these estimates and those need to be acknowledged and addressed. Recent work has shown, for example, that emission factors are not constant values as assumed in the report, but depend strongly on the type of well (conventional vs. unconventional) as well as the throughput (Omara et al., 2016). There is evidence to suggest that higher producing natural gas wells leak a smaller fraction of their produced methane to the atmosphere. Higher producing wells are often newer, have more modern equipment and the operators have more incentive to maintain them properly, so this makes sense. While there is

PR-1-1

insufficient information to improve the emissions estimates in the report, the resulting uncertainties should be described and can even be quantified to some extent. For example, the functional dependence of methane emission factors on throughput can be taken from the literature (Omara et al., 2016) and used for the present analysis to quantify how sensitive the emission results are to these different assumptions. Also, a more detailed analysis of the extensive results listed in Tables D-12 and D-13 might give information on how emission factors depend on throughput for wells in California. As far as I could tell, these results are only used in the report to determine average emission factors for different parts of the oil and gas production infrastructure. Evidence from the Uintah basin in Utah has shown that emissions estimates based on the same methods as used here underestimated methane emissions by a factor of ~5, underestimated VOC emissions by factor of ~2, and overestimated NOx emissions by a factor of ~4 (Ahmadov et al., 2015). Similarly large uncertainties in emissions estimates for methane have also been reported in the Denver-Julesburg basin in Colorado (Petron et al., 2012). These are not small effects and this needs to be acknowledged and addressed in the report.

PR-1-1
cont.

I also have the following **Big Picture Comment**:

Given the uncertainties described above, a verification effort to evaluate the regional emissions of methane before, during and after the implementation of the proposed regulation appears to be a highly desirable addition to the plans. This would provide evidence for the success of the regulations and could also be useful to adjust the regulation to be more (cost)effective. In addition, by documenting the effects on methane and air pollutant emissions of these regulations, the State of California has the unique opportunity to provide a blueprint for other states on how to effectively reduce methane emissions from the oil and gas industry. The report describes that most of the emissions reductions are anticipated in the San Joaquin Valley. A monitoring program or a series of targeted studies would allow the quantification of regional emissions of methane and air pollutants in the San Joaquin Valley before, during and after the implementation of the proposed regulation.

PR-1-2

Detailed comments:

Many of the figure references in the "Staff Report: Initial Statement Of Reasons" are off. In most cases, it was clear what figure or Table was referred to, but some more careful proofreading would have been useful.

PR-1-3

Page ES-1, "*Methane is 72 times more potent than CO2 as a GHG when considered on a twenty year time frame.*": please add a reference. Also, note that the IPCC AR5 report has a different number for the 20-year global warming potential of methane (84, as mentioned later in the report). The difference is due, in part, to the way that the direct and indirect effects of reactive trace gases on radiative forcing were accounted for in AR5.

PR-1-4

Page 2, "*Their relative climate forcing (or impact), when measured in terms of how they heat the atmosphere, (see explanation of global warming potential in footnote 10) can be tens, hundreds, or even thousands of times greater than that of CO₂.*": more accurately, the climate forcing on a per-molecule basis can be much larger than for CO₂. As written, the sentence may be understood that the total forcing of methane is higher than of CO₂, which is not the case.

PR-1-5

Page 29 and 30, Tables 5 and 6: the source of these numbers was unclear.

PR-1-6

References

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Petron, G., Frost, G., Miller, B. R., Hirsch, A. I., Montzka, S. A., Karion, A., Trainer, M., Sweeney, C., Andrews, A. E., Miller, L., Kofler, J., Bar-Ilan, A., Dlugokencky, E. J., Patrick, L., Moore, C. T. J., Ryerson, T. B., Siso, C., Kolodzey, W., Lang, P. M., Conway, T., Novelli, P., Masarie, K., Hall, B., Guenther, D., Kitzis, D., Miller, J., Welsh, D., Wolfe, D., Neff, W. and Tans, P.: Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study, *J. Geophys. Res.-Atmos.*, 117(D4), D04304, doi:10.1029/2011JD016360, 2012.

**EXTERNAL PEER REVIEW OF THE TEST PROCEDURE FOR DETERMINING ANNUAL
FLASH EMISSION RATE FROM CRUDE OIL, CONDENSATE, AND PRODUCED WATER
TANK AND SEPARATOR SYSTEMS**

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AFFILIATION: The University of Oklahoma

DATE: 23rd November 2016

Overview.

The California Air Resources Board (ARB) staff have developed a test procedure whose intended purpose is to quantify emissions from crude oil, condensate and produced water separator and tank systems that are open to the atmosphere. Fluid phase behavior (existence and stability of liquid and vapor phases at equilibrium) is governed by fluid composition, pressure and temperature. As produced fluids move downstream to tanks or separators used to separate or store liquid hydrocarbon or produced water, it is possible that gas previously dissolved in the liquid phase may be released. If vented to the atmosphere, the released gas may contribute to overall greenhouse gas emissions.

The procedure for determining the volume and composition of the released gas is as follows:

1. A liquid sample (oil, liquid condensate, produced water) is collected upstream of the separator or tank where flashing may occur. These samples will be collected under pressure to replicate conditions in the flowlines leading to the separator.
2. The sampling methods include a double valve cylinder for crude oil/produced water samples or a cylinder with a pressurized piston for collecting lighter oils/condensate/produced water samples.
3. The collection of at least one duplicate sample is recommended and necessary in order to ensure repeatability of the test results.
4. The collected samples are then sent to a laboratory where the samples are re-heated to the sample collection temperature for 30 minutes. After the temperature is stabilized, the cylinder is opened to atmospheric conditions and all the released gas is collected, its volume measured at 60F and 14.696 psi and its composition measured.
5. The volume of oil/liquid condensate/produced water is also recorded at 60F and 14.696 psia.
6. The gas-oil/gas-water volume ratios from the previous two steps are then used to calculate net emission rates in Mass/Year of gas and methane.

Review:

My review addresses the overall readability of the test procedure as well as the three conclusions listed in Attachment 2 '*Description of Scientific Bases of the Test Procedure to be addressed by the Peer Reviewer*'. The conclusions listed below are sourced from Attachment 2 and the review immediately follows each conclusion.

Conclusion 1: The test procedure provides a sound approach for taking samples of oil, condensate, produced water upstream from the oil and gas separator and tank systems.

In general, the procedure documented using a double valve cylinder or a piston cylinder to acquire liquid samples is reasonable. There are a few technical comments that need addressing:

1. In Section 7.2, the list of data to be recorded on the sample cylinder identification tag is provided. Item (e) specifies 'percent water cut' defined in Section 3.14 as 'volume percentage of produced water to crude oil or condensate'. In the oil industry, the water cut is defined as the volume percentage of produced water to the total liquid flow rate (water plus oil or condensate). The inconsistency in definitions may lead to inconsistencies in reported data. PR-2-1
2. The sampling procedure described does not explicitly document an approach for collecting liquid samples when both oil (or liquid condensate) and water is being produced. If both oil and water are to be tested for gas emissions, in what ratio should they be collected and how? Ignoring one or the other liquid phase can either underestimate or overestimate gas emissions. PR-2-2
3. In Figure 1 and in Section 8.10, the valve D is opened to allow for a slow displacement rate of the non-reactive displacement liquid at a rate of 3 drips/second to prevent the collected liquid from flashing. Likewise in Figure 3 and Section 9.7, the liquid sample is collected at 150-200 ml/second. This procedure needs to be more quantitative. What should the downstream pressure be in relation to the upstream pressure (Gauge N versus Gauge M in Figure 3)? Should there be a downstream gauge in Figure 2 and Section 8.10 and what is an acceptable pressure PR-2-3

differential. For relatively high pressure sampling points, it may require the tester to determine the extent that valve D opens by trial-and-error and may lead to erroneous sample collection. If an acceptable range for the pressure differential is provided, this may become less subjective. However, a recommended pressure range may also require higher precision pressure gauges than those provided in Section 5.1 and 5.2. As an example, the procedure outlined in GPA 2174-93 is a more suitable and precise approach for sample collection.

PR-2-3
cont.

4. In Section 8.16 and Section 9.13, the test procedure calls for the sample to be transported to the laboratory after ensuring that the valves are closed. Unless the valves are tested periodically, this is likely to lead to inaccuracies in the data reported. I recommend that each sample collection cylinder come with its own pressure gauge(s). The pressure values in the sample collection cylinder should be recorded immediately after sample collection and again, prior to testing in the lab at the sample collection temperature to ensure that no fluid has leaked. This will also ensure that when the sample is heated as specified in Section 10.3(a), the pressure in the sample chamber returns to the same value it was collected at.

PR-2-4

Conclusion 2: The test procedure provides a sound approach for preparing and analyzing samples of oil/condensate and produced water from oil and gas production separator and tank systems for constituents and properties needed to estimate emissions from flashed gases from such separator and tank systems.

I do not have anything to add to this conclusion and find that the recommended procedures are sound.

PR-2-5

Conclusion 3: The test procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production separator and tank systems.

The calculations outlined as a part of the test procedure are sound. The test procedure needs to however provide a more explicit approach for computing cumulative gas and methane emissions when the produced liquid comprises both oil/condensate and water

PR-2-6

phases. For instance in Section 11, the test procedure indicates that ‘The same calculations are used for crude oil, condensate and produced water’ should be modified to read ‘The same calculations are used for crude oil, condensate and produced water and the cumulative mass of methane emissions is calculated as the summation of annual mass of methane from each source’ or something analogous.

PR-2-6
cont.

Other Comments:

Big Picture. Reviewers are not limited to addressing only the specific assumptions, conclusions and findings presented above and are also asked to contemplate the following questions.

(a) In reading the staff report and supporting documentation, are there any additional substantive scientific issues that were part of the scientific basis or conclusion of the proposed oil and gas regulation but not described above?

In reading the ‘Initial Statement of Reasons’ (ISOR) prepared by California ARB, I note that the net methane emissions from oil and gas extraction process losses (Figure 1 in the ISOR) constitute less than 4% of the overall methane emissions in the State of California. Agriculture and landfills constitute close to 80% of the net methane emissions. I strongly support regulation of greenhouse gas emissions; however I feel that unless corresponding regulation is being proposed to address emissions from other significantly larger sources, the test procedure as a part of the proposed regulation of the oil and gas industry will have a very limited impact on reaching a 40% reduction in methane emissions by 2030.

PR-2-7

(b) Taken as a whole, are the conclusions and scientific portions of the proposed oil and gas regulation based upon sound scientific knowledge, methods and practices.

In general, the proposed test procedure is largely free of any scientific issues or oversights except as outlined above.

PR-2-8

Quality of the figures/text

The readability of the test procedure and the quality of the figures/tables provided is good.

PR-2-9

SUMMARY REPORT OF THE SCIENTIFIC PEER REVIEW OF THE TEST PROCEDURE FOR DETERMINING ANNUAL FLASH EMISSION RATE OF METHANE FROM CRUDE OIL, CONDENSATE AND PRODUCED WATER

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November 10, 2016

Introduction

As part of an initiative by the State of California Air Resources Board (ARB) to reduce greenhouse gas emissions, regulations have been proposed. The Proposed Regulation for Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities (Oil and Gas Regulation) is given in Appendix A of the Initial Statement of Reasons (ISOR) document of May 31, 2016. Part of the regulations involve standardizing test procedures for determining annual flash emissions from vessels or tanks that store crude oil, hydrocarbon condensate and water. The summary and rationale for each section of the Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate and Produced Water Tank and Separator Systems (Test procedure) is described in the ISOR on pages 78-83. The Test Procedure itself is given in Appendix C of the Oil and Gas Regulation. The ARB has requested that the Test Procedure be subject to scientific peer review.

As per Attachment 2 of the memo to Dr. Gerald Bowes, Manager, Cal/EPA Scientific Peer Review Program from the Office of Research, Planning and Performance of the State Water Resources Control Board on August 10, 2016, the Test Procedure scientific peer review has been divided into four conclusions.

The purpose of this report is to summarize a scientific peer review of conclusion 1:

1. The Test Procedure provides a sound approach for taking samples of oil, condensate and produced water upstream from oil and gas production separator and tank systems. The approach is described in Sections 1-9 of the Test Procedure, Appendix C of the Oil & Gas Regulation. A summary and rationale for these sections can be found on pages 78-81 of the ISOR.

The scientific peer review was initiated and this report are in response to the letter of October 26, 2016 from Dr. Gerald Bowes to the author.

Scientific Peer Review Results

Section 1 of the Test Procedure briefly discusses the Purpose and Applicability while Section 2 is the Principle and Summary of the Test Procedure and mentions that there are two methods, one involving a double cylinder and the other involving a piston cylinder. Section 3 is Definitions while Section 4 summarizes Biases and Interferences that can affect results. Sections 5 and 6 discuss Sampling Equipment Specifications and Sampling Equipment, respectively, and Section 7 lists Data Requirements required prior to sampling. Section 8 details the Double Valve Cylinder Sampling Method while Section 9 details the Piston Cylinder Sampling Method.

These sections were reviewed for common sense, accuracy and consistency and the procedures of Sections 8 and 9 were compared to GPA 2174-93. The results of the review are presented below as comments and suggested modifications pertaining to the procedure number.

Test Procedure Review Comments for Sections 1-9

4.3 State when samples are to be taken. For example: Samples shall not be collected from a pressure separator or portable pressurized separator while it periodically drains liquids but should be collected during periods liquids are not being drained.	PR-3-1
4.6 State how often gauges should be calibrated. For example: All pressure and temperature measurements shall be conducted with calibrated gauges as specified in this procedure and these gauges should be calibrated twice per year.	PR-3-2
4.8 The collection and testing of duplicate samples is recommended in order to verify the reported results. At least two samples are required but three samples are preferred.	PR-3-3
5.1 Since even a small inaccuracy can change the results, more accurate pressure gauges are recommended. For example: A pressure gauge capable of measuring liquid pressures of less than 50 pound per square inch gauge pressure within +/-5% accuracy.	PR-3-4
5.2 Since even a small inaccuracy can change the results, more accurate pressure gauges are recommended. For example: A pressure gauge capable of measuring liquid pressures greater than 50 pounds per square inch gauge pressure within +/- 3% accuracy.	PR-3-5
6.4 High-pressure rated metal components and control valves that can withstand the temperature and pressure of the pressure vessel or portable pressurized separator	PR-3-6

being sampled and should at least match the design pressure and temperature of the system being sampled.	PR-3-6 cont.
7.2 (b) The separator temperature and pressure must be known (not optional), either from instruments on the vessel being sampled or the sample train.	PR-3-7
8.1 Add why condensate the piston cylinder method is preferred for condensate samples. For example: The double valve cylinder sampling method is used for collecting crude oil or produced water samples and is not applicable for collecting samples of condensate due to potential sample flashing.	PR-3-8
8.6 Make the boundary clear between the existing sample port fittings on the vessel of interest and the sample train. This can be done by stating that valve A is the sample source valve as follows: Connect the sampling train as illustrated in Figure 1 to the sampling port on the pressure separator or portable pressurized separator at the outlet of the sample source valve A while minimizing tubing between the purge valve and cylinder as shown. Bushings or reducers may be required.	PR-3-9
8.7 Note that depending on the pressure drop across the sampling train purge valve, there will likely be some bubbles in the liquid stream. This can be added to the wording as follows: Purge the sampling train: Place the outlet of valve B into the waste container. With valves B, C and D closed, slowly open valve A completely, and then slowly open valve B to purge the sample train until a steady stream of liquid without gas pockets is observed, and then close valve B. Note that there may be some bubbles in the liquid stream due to some flashing across purge valve B.	PR-3-10
8.10 Slightly modify the valve closure wording. Continue until 80 to 95 percent of the displacement liquid is measured in the graduated cylinder, then close valves D and then C.	PR-3-11
8.13 The sample source valve needs to be closed before the sample cylinder can be removed so modify wording as follows: Close sample source valve A then disconnect the sample cylinder from the sampling train and verify that both valves are sealed.	PR-3-12
8.14 Since valve A needed to be closed in 8.13, modify this procedure as follows: Remove sampling train: With valves A, D and C closed, purge any remaining liquid in the sampling train through valve B and then close valve B. Disconnect the sampling train from the pressure separator or portable pressurized separator at the outlet of sample source valve A.	PR-3-13
Note that if these procedures do not consider valve A as the sample source valve, then they need to be modified to include a sample source valve located on the outlet of the existing sample port of the vessel of interest.	PR-3-14

The double valve cylinder valves should be periodically leak tested (once per year) with an inert gas and a statement should either be added to the beginning of this section or added to Section 6.

PR-3-15

9.1 The pressure of the inert gas needs to be added to the procedure, perhaps as follows: Locate a pressure separator immediately upstream of the separator or tank required for testing and verify it is pressurized to at least 15 psig. Install a portable pressurized separator if no pressure separator is available immediately upstream of the separator or tank that can be used to collect condensate and produced water samples. Ensure the inert gas in the piston cylinder is at least at the sampled vessel pressure or preferably a 3-5 psi above it.

PR-3-16

9.4 As in the previous procedures, make the boundary clear between the existing sample port fittings on the vessel of interest and the sample train. This can be done by stating that valve A is the sample source valve as follows: Connect the sampling train as illustrated in Figure 3 to the pressure separator or pressurized portable separator at the outlet of the sample source valve A while minimizing tubing between the purge valve and cylinder as shown. Bushings or reducers may be required.

PR-3-17

9.5 As in previous procedures, note that depending on the pressure drop across the sampling train purge valve, there will likely be some bubbles in the liquid stream. This can be added to the wording as follows: Purge the sampling train: Place the outlet of valve B into the waste container. With valves B, C and D closed, slowly open valve A completely, and then slowly open valve B to purge the sample train until a steady stream of liquid without gas pockets is observed, and then close valve B. Note that there may be some bubbles in the liquid stream due to some flashing across purge valve B.

PR-3-18

9.7 State how the sampler is to judge how the filling rate of the cylinder and the volume collected. Is this done by an indicator rod? Or, perhaps the sampler just needs to follow manufacturer's instructions. Add a statement as follows: Collect liquid sample: With valve A opened and B closed, slowly open Valve D to allow liquid to enter the piston cylinder at a rate of 150 to 200 milliliters per minute until 80 to 95 percent of the cylinder is filled with liquid, as per manufacturer's instructions for cylinder indication. Do not allow pressure M to drop below the sampling pressure. Then close valves C and D.

PR-3-19

9.10 Valve A must be closed before the sampling train can be removed so modify the procedure as follows: Close sample source valve A then disconnect the sample cylinder from the sampling train and verify that both valves C and D are sealed.

PR-3-20

9.11 Remove sampling train: Place the outlet of valve B into the waste container and slowly open valve B to purge all liquid from the sampling train and then close valve B. Disconnect the sampling train from the pressure separator or portable pressurized separator at the outlet of sample source valve A.

PR-3-21

Note that if these procedures do not consider valve A as the sample source valve, then they need to be modified to include a sample source valve located on the outlet of the existing sample port of the vessel of interest.

PR-3-22

The piston cylinder should be leak tested across the piston periodically (once per year) with an inert gas so this should be added to either at the beginning of this section or added to Section 6.

PR-3-23

Conclusion

The test procedure needs some modifications as outlined in this peer review report and with these modifications would provide a sound approach for taking samples of oil, condensate and produced water upstream from oil and gas separator and tank systems.

PR-3-24

Review comments for "Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate, and Produced Water"

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November 20, 2016

This procedure describes methods for determining flashing emissions (releases of volatile gases, particularly methane, entrained in liquids) from oil, condensate, and produced water associated with oil and natural gas development. Emissions estimates are required to determine appropriate actions based on the proposed greenhouse gas emissions standards for oil and natural gas facilities in California.

Briefly, the procedure has three major steps: (1) sample collection on-site, (2) sample analysis to determine gas/liquid ratios and methane content of flashed vapors, and (3) estimation of annual emissions from the gas/liquid ratio, annual liquids production, and operating days per year. All sampling and analysis steps reference test procedures published by ASTM, U.S. EPA, and GPA (Gas Processors Association). Overall, the proposed method provides a reasonable framework for estimating greenhouse gas emissions from flashing. PR-4-1

This review was performed in response to an August 10, 2016 California Air Resources Board request for review signed by Elizabeth Scheehle, Chief, Oil and Gas and GHG Mitigation Branch placed to Gerald Bowes, Manager of the CalEPA Scientific Peer Review Program. Dr. Bowes invited my participation in the peer review process in a letter dated August 22, 2016. In particular, it is Attachment 2 of the August 10 letter which is the focus for reviewers, and which contains the conclusions to be reviewed. Attachment 2 describes the scientific basis of the test procedures for the proposed rule.

My suitability to perform this review, and my perspective in making comments, relies primarily on my recent research. My research group has conducted several projects to measure methane emissions from oil and gas facilities, with a specific focus on methods to determine facility-wide emissions of methane and other gases using mobile sampling techniques such as the tracer flux method. We have used the data collected at numerous O&G facilities to scale up our measurements to basin-wide estimates. We recently published estimates of methane emissions from natural gas wells in the Marcellus Shale in Pennsylvania and West Virginia (M. Omara et al, *Environmental Science & Technology*, 2016), and are currently expanding our analysis to include the ten largest gas basins in the continental US.

Below, I provide comments based on three specific conclusions posed to the reviewers.

Comments related to Conclusion #1: "The test procedure provides a sound approach for taking samples of oil, condensate, and produced water upstream from oil and gas production separator and tank systems." (Sections 1-9 of the test procedure and pages 78-81 of the ISOR)

1. Based on review of the attached Test Procedures, the proposed sampling methods appear appropriate. PR-4-2
2. The procedures outlined in Sections 1-9 should provide samples of sufficient quality to determine flashing emissions. PR-4-3

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|---|--------|
| 3. To maintain consistency with the text above it, Item 3.8 should note that flashing can occur both when pressure falls or when temperature increases. | PR-4-4 |
| 4. Steps 9.6 and 9.7 both say to open valve D. This is confusing - it seems like users are supposed to open the valve twice without closing it between steps. Also, once valve C and D are both opened, sample will enter the piston sampler, even if the pressure is not equalized. | PR-4-5 |
| 5. Should the procedure include language about the required cleanliness of double valve or piston samplers prior to sampling or describe the procedures to clean samplers between samples? GPA 2286-95 notes that samplers need to be cleaned, but it may be worthwhile to reiterate this in the test procedure document. | PR-4-6 |

Comments related to Conclusion #2: "Test procedure provides a sound approach for preparing and analyzing samples of oil, condensate, and produced water. . ." (Sections 10, 12-14, and test method files)

- | | |
|--|---------|
| 1. The relevant sections of the test procedure and attached test methods seem appropriate to achieve the goals of the sample analysis. | PR-4-7 |
| 2. It may be worthwhile to mention the information in item 10.1(b) (duplicate sample collection) in the preceding sections (8 and 9) describing sample collection. Different personnel may read different, and limited, portions of the test procedure, and it may help personnel charged with collecting samples to have the duplicate sample criteria stated explicitly along with sampling procedures. | PR-4-8 |
| 3. 10.2(d) and other references to sample temperature. While it is likely that under most conditions the sample will be collected at temperatures above typical room temperature, situations may arise when the sample temperature is below typical room temperature. The procedure should outline what steps to if this is the case. | PR-4-9 |
| 4. 10.3(d) 0.2 cubic feet per barrel of liquid are very inconvenient units, especially since samples are collected in milliliters (and I presume most lab technicians will work in milliliters in the laboratory). It would be useful to note typical gas volumes. E.g., for a sample with a 500 ml total volume, the gas volume must be at least 24 ml (assuming the same temperature and pressure for the liquid and gas and 31.5 gallons per barrel). | PR-4-10 |
| 5. 12.1.a - what are storage requirements for the sketch? Hard copy, electronic, or both? Please specify. | PR-4-11 |

Comments related to Conclusion #3: "The test procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production. . ." (Section 11)

- | | |
|---|---------|
| 1. Annual flash emissions are estimated by collecting a sample, determining the gas/oil ratio, and then applying that ratio across the entire year. It seems that the annual emissions are therefore calculated from a single sample collected somewhere during the course of a year. This may create some uncertainty in the estimate of annual emissions, as described below. | PR-4-12 |
| 2. The calculations used to determine the annual emission rate (Equations 1-3 in Section 11) are all appropriate. | PR-4-13 |
| 3. It is difficult to tell if the approach outlined in the method represents an upper or lower bound estimate for annual emissions. It will depend in large part on whether or not the sample was collected on a day with "normal" operations. For example, how the sampling temperature compares to typical temperatures over the year. | PR-4-14 |
| 4. The body of research surrounding methane emissions from O&G consistently shows the importance of super emitters. This is sometimes referred to as a fat-tail problem. Most facilities have low emissions, and a small number of facilities have large emissions. These super emitters dominate the overall emissions. For example, in many cases 10% or 20% of the sites sampled | PR-4-15 |

contribute more than 50% of the total emissions. A key strategy in reducing overall emissions is to target super emitters. Recent research from the Environmental Defense Fund and other groups suggests that super emitters are the result of unwanted process conditions – tanks with relief valves stuck open or other major leaks that can be remedied through maintenance. One complication regarding super emitters is whether or not super emitting sites have consistently high emissions (“once a super emitter, always a super emitter”) or if the large emissions are episodic.

PR-4-15
cont.

Thus questions to consider regarding the proposed test method are (i) whether or not super emitters will be identified, and (ii) if emissions from sites identified as super emitters will be consistently high, or if the emissions will change over time. The answer to the first question is likely “yes.” The second question is more difficult, as there is uncertainty in what creates super emitters, and all of the contributing variables are not known. In my opinion, one potential way to help flag the potential for super emitters will be to note how variables (temperature, production volume) on the day of sampling compare to typical annual values.

5. A second possibility for verifying super emitters would be to require follow up sampling if the calculated annual emissions are above a certain threshold. E.g., sites with the top 5% or 10% of calculated emission rates (or gas/oil ratios, which is used to calculate annual emissions) could be retested soon after the initial test in order to determine if the emissions are consistently high.

PR-4-16

6. The method employed here assumes that: (i) the analyzed sample is representative of produced liquids on the day of sampling, (ii) that the same composition of liquids (water and oil) and flashing vapors persist over the course of the year, and (iii) that operating and ambient conditions on the day of sampling are representative of the entire year. The first assumption can be checked by comparing two separate samples collected on the same day. Verifying assumption (ii) would require collecting samples on multiple days or at different times of year. It is not clear if collecting multiple samples each year is within the scope of the proposed rules. The third assumption can be verified by comparing operating conditions on the day of sampling to typical day-to-day conditions, and by comparing ambient outdoor temperature on the sampling date to historical meteorological data.

PR-4-17

7. It may be worthwhile to implement a system to “flag” data or sampling dates that fall outside of the typical range, e.g., if samples were collected on an abnormally hot or cold day.

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8. The annual flash emissions estimate also seems to tacitly assume that all flashed vapors are vented to the atmosphere (e.g., that no vapor recovery or destruction systems are in place). Assuming all flashed vapors are released to the atmosphere would help push the estimated emissions towards the upper limit, though that estimate may be tempered by some of the other uncertainties listed above. If a flashed vapor recovery system is in place, the proposed method would likely over estimate emissions. For sites with flashed vapor recovery or vapor destruction systems, it may be worthwhile to calculate the potential emissions using the proposed method, as well as the expected emissions, where the latter assumes a recovery or destruction efficiency.

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